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Heavy metal hyper accumulation potential of local flora from polluted areas of Delhi

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ABSTRACT

Phytoremediation is a cost-effective in-situ technique that exploits plant physiology for environmental remediation. Using local flora for phytoremediation has the advantage of successful revegetation and prevents leaching of the pollutants, such as heavy metals. The present study focused upon the hyperaccumulation potential of six local plants, namely *Cannabis sativa, Datura metel, Amaranthus viridis, Parthenium hysterophorus, Oxalis corniculata,* and *Bryophyllum pinnatum,* against copper, cadmium, zinc, chromium, and lead. *P. hysterophorus* was the most adapted hyper accumulator, as despite co-accumulation of Cu (331.45 mg/kg), Cd (243 mg/kg), and Zn (440.66 mg/kg), its phenols, superoxide dismutase (SOD), and peroxidase (POD) levels remained stable, indicating high metal tolerance. Similarly, stable antioxidant defense was also observed in *O. corniculata* despite Zn and Cr phytostabilization and Cd phytoextraction. Although *D. metel* accumulated the highest Cd and Cr levels, its elevated phenols, tannin, SOD, and POD indicated less adaptability to heavy metal stress. In contrast, *B. pinnatum* showed Cd phytoextraction (roots, 206.72 mg/kg; shoot, 248.80 mg/kg) and Cr phytostabilization (roots, 826.06 mg/kg), with a stable antioxidant response. *A. viridis* showed phytostabilization only for Cr, whereas *C. sativa* did not show significant hyperaccumulation potential. The results suggest that the phytoremediation capacity of tested plants on multi-contaminated sites is in the order *P. hysterophorus* > *O. corniculate* > *D. metel* > *B. pinnatum* > *A. viridis* > *C. sativa.*

Introduction

Conventional techniques of soil remediation contaminated with pollutants, such as heavy metals, have been practiced for many decades. However, besides being costly, energy-intensive, and metal-specific (Khalid *et al*., 2017; Aparicio *et al*., 2022), they produce a large quantity of sludge (Ojuederie and Babalola, 2017). Moreover, these processes do not purge the soil completely of its contaminants and merely transfer them to a different place where they need to be monitored continuously (Saleem *et al*., 2023). To overcome these disadvantages, phytoremediation can be an effective strategy, which utilizes the capability of plants, wild weeds, or plant microbes to mitigate the impact of pollutants such as sewage sludge, toxic heavy metals, radionuclides, and organic substances from soil (Dushenkov, 2003; Paz-Ferreiro *et al*., 2014; Gautam *et al*., 2021). Phytoextraction is a cost-effective, energy-efficient, novel, eco-friendly, and solar-driven component of phytoremediation (Seth *et al*., 2012). Through this process, plants can also be utilized as bio-ores of heavy metals, and in large-scale applications, the potential energy thus produced can be used to generate thermal energy (Ghosh and Singh, 2005; Dhiman *et al*., 2024).

There are two main phytoextraction strategies proposed to remediate toxic metals from soil. The first approach involves the use of metal hyper accumulator plants (Banuelos, 2006; Sytar *et al*., 2021; Reeves *et al*., 2021). Hyperaccumulators are capable not only of growing in contaminated soil but also of absorbing an enormous quantity of metals through their roots and have the ability to grow on contaminated soil (Van der Ent *et al*., 2013; Sheoran *et al*., 2016). On average, these plants accumulate >1000 mg/kg of Cu, Co, Cr, Ni, and Pb or 10000 mg/kg of Fe, Mn, and Zn in their shoot dry matter (Market, 2003; Liu *et al*., 2016; Midhat *et al*., 2019). The

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